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## Study on LiBr-Liquid Desiccant System Driven by Heat Pump

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### Abstract

Humidity is one of the most important factors for human thermal comfort, and the liquid desiccant system is an effective dehumidification mode, especially for renewable energy such as solar energy or waste heat acting as the driving heat. The whole system performance is depended on high absorption (or desorption) of water vapor in absorption (or desorption) process. Moreover, the cooling and heating energy should apply to absorption and desorption process respectively since the latent heat of water vapor transferred between air and liquid desiccant solution. However, in a real system, cooling and heating energy are always independent and matching imperfectly. In this study, heat pump is applied in a liquid desiccant system as the cooling and heating energy which can use thoroughly. Moreover, lithium bromide is acted as the working solution which is focused on experimentally test. Furthermore, different operating conditions including moist air temperature, air humidity, air flow et al in absorber and in generator are measured in the experiment test. Consequently, the experimental results is given and analyzed.

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**Keywords:** Liquid desiccant; LiBr-solution; Dehumidification; Heat pump

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### 1. Introduction

Humidity is one of the most important parameters in air conditioning and living environment, it affects not only the body's thermal comfort, but cause great impact on food, goods, clothes etc., and even the structure of building envelope. Especially, in hot and moist region, it is absolutely necessary to adjust humidity to the comfortable conditions. The liquid desiccant system is more effective than the conventional vapor compression system when the latent load is large in comparison to the sensible load. Hence, it receives high attentions and rapidly developed recently [1-4]. Due to

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being advantageous in handling latent heat load, liquid desiccant system with different working pair such as lithium bromide solution, lithium chloride solution, calcium chloride solution etc., have been studied and used widely [5-7]. On the other hand, in order to obtain high performance of the system, the extra cooling and heating energy should be applied to absorption and desorption process respectively since the latent heat of water vapor transferred between moist air and liquid desiccant solution.

In this study, heat pump is applied in liquid desiccant system as the cooling and heating energy which can use thoroughly, and an auxiliary heat source is added to fetch up the unbalanced energy. Moreover, lithium bromide solution with 50% mass concentration is acted as the working solution which focused on experimentally test of absorption and desorption process. Furthermore, different operating conditions including moist air temperature, air humidity, air flow, and the lithium bromide solution flow ratio in absorber and in generator are measured in the experiment test.

## 2. Experimental test

In order to test the absorption and desorption performance of LiBr-liquid desiccant system driven by heat pump, an experimental system was set up which shown in Fig. 1. The heat pump system including the compressor (Model: THU33WC6-U), the thermal expansion valve (Model: TX2-068Z3206), and the evaporator (finned tube heat exchanger) and the condenser (finned tube heat exchanger), the refrigerant of heat pump is R22. The dehumidified air flow from the bottom of evaporator to the top while the strong LiBr solution spray from the top to the bottom, as a result, a countercurrent heat and mass transfer between strong LiBr solution and moist air happened, simultaneously, the moist air and the LiBr solution is cooled by evaporator, therefore, the evaporator can also be called evaporative dehumidifier. Similarly, the regeneration air flow from the bottom of condenser to the top while the weak LiBr solution spray from the top to the bottom, as a result, a countercurrent heat and mass transfer between weak LiBr solution and moist air happened, simultaneously, the regeneration air and the LiBr solution is heated by condenser, hence, the condenser can also be called condensing regenerator.

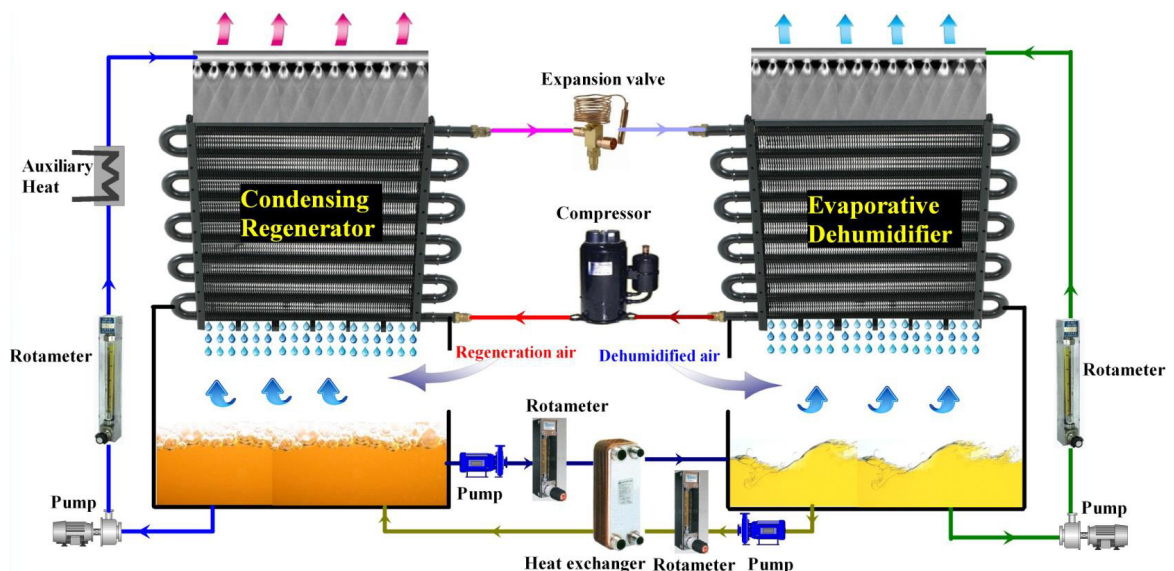


Fig. 1. Schematic of LiBr-liquid desiccant system driven by heat pump.

Fig. 2 shows the basic structure and parameters of evaporative dehumidifier and condensing regenerator in a single finned tube heat and mass exchanger. For evaporative dehumidifier in the system, 4 finned tube heat and mass exchanger are connected in series, and for condensing regenerator, 6 finned tube heat and mass exchanger are

connected in series. The material of the finned is aluminum foil, and the size parameters of aluminum foil is 530 mm in length, 54 mm in width and 0.4 mm in thickness, and the fin pitch is 4 mm. Moreover, the size parameters of refrigerant copper pipe is 9.52 mm in diameter and 0.35 mm in wall thickness. Furthermore, there is a heat exchanger between the strong LiBr solution pool and the weak LiBr solution pool to recovery the heat. The flow meters can measure and control the solution flow rate when adjust the system conditions.

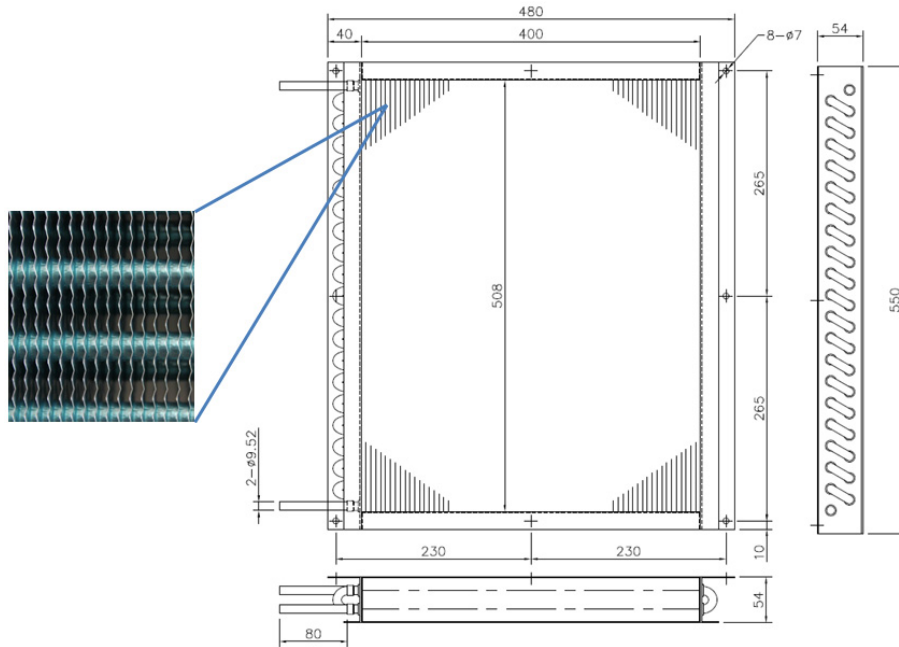


Fig. 2. Basic structure of a single finned tube heat and mass exchanger.

The absorption and desorption performance are decided by the heat and mass transfer process between the moist air and the liquid solution no matter whether in evaporative dehumidifier or in condensing regenerator, therefore, the experiments will focus on the key parameters of moist air and LiBr-solution which cooled or heated by heat pump. Specifically, only one kind of inlet parameter of moist air or LiBr-solution is adjusted when other parameters keep constant, the inlet parameters of moist air including the air temperature, the absolute humidity of moist air and the air velocity, and the inlet parameters of LiBr-solution mainly refers to the solution flow rate.

### 3. Results and analysis

#### 3.1. Absorption performance in evaporative dehumidifier

##### 1) Influence of dehumidified air temperature

Fig. 3 shows the dehumidification capacity in the evaporative dehumidifier along with the moist air temperature, the other parameters in the evaporative dehumidifier keep constant which also shown in Fig. 3. As is known, the driven force of water vapor mass transfer is the water vapor partial pressure difference between the LiBr-solution and moist air. Therefore, when the air temperature increase, although the water vapor partial pressure of moist air is increased, however, the heat transfer between the moist air and the LiBr-solution enhanced, and the temperature of LiBr-solution will increase, and wholly, the water vapor partial pressure between the LiBr-solution and moist air will decrease, as a result, the water vapor mass transfer decrease.

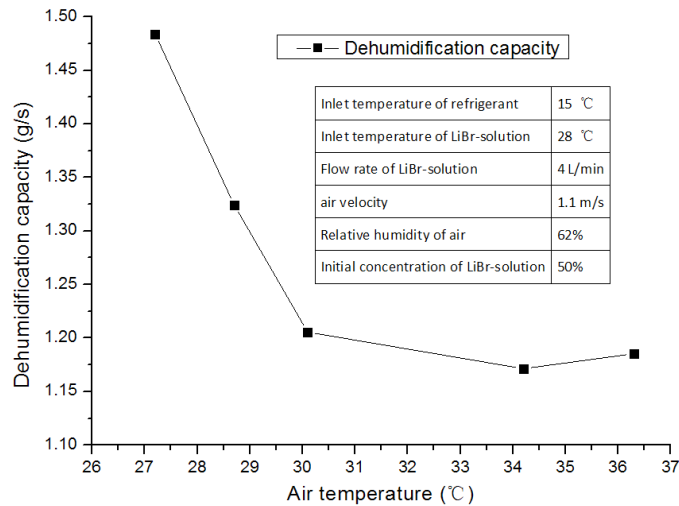


Fig. 3. Dehumidification capacity along with air temperature.

## 2) Influence of dehumidified air velocity

Fig. 4 shows the dehumidification capacity in the evaporative dehumidifier along with the air velocity, the other parameters in the evaporative dehumidifier keep constant which also shown in Fig. 4. As the air velocity increase, the heat and mass transfer between LiBr-solution and the moist air will increase, and the water vapor pressure difference is increased, then, the dehumidification capacity is grown up.

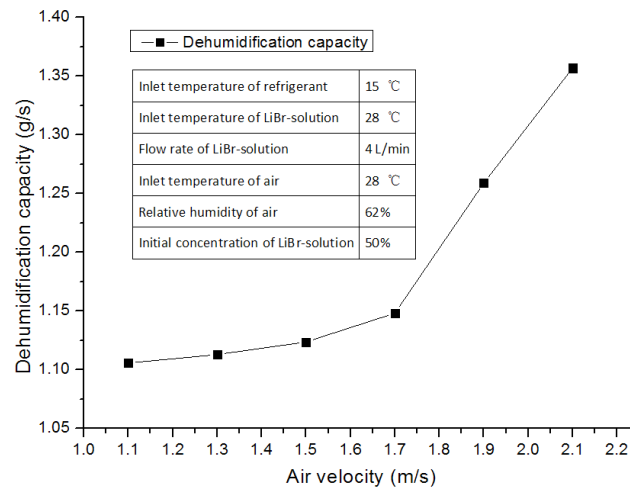


Fig. 4. Dehumidification capacity along with air velocity.

## 3) Influence of LiBr-solution flow rate

Fig. 5 shows the dehumidification capacity in the evaporative dehumidifier along with the LiBr-solution flow rate, the other parameters in the evaporative dehumidifier keep constant which also shown in Fig. 5. As the LiBr-solution flow rate increase, the film thickness which covered in fin and tube increased, and the contact area between LiBr-

solution and air enhanced, as a result, the water vapor partial pressure difference increased, then, the dehumidification capacity grew up.

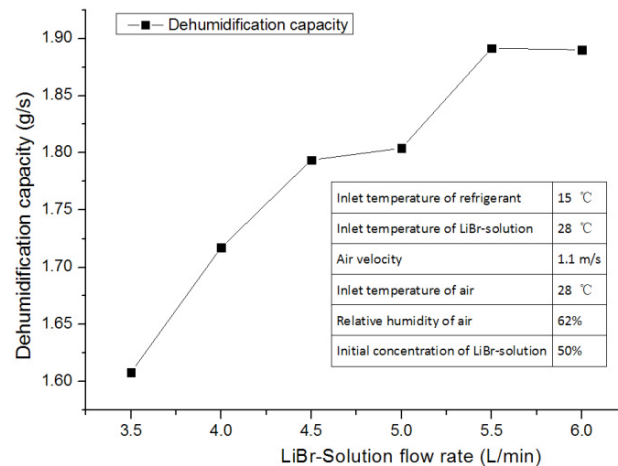


Fig. 5. Dehumidification capacity along with LiBr-solution flow rate.

#### 4) Influence of air moisture content

Fig. 6 shows the dehumidification capacity in the evaporative dehumidifier along with the moist air velocity, the other parameters in the evaporative dehumidifier keep constant which also shown in Fig. 6. When the air moist content increase, the water vapor partial pressure will increase, as a result, the driven force of water vapor mass transfer increase, then, the dehumidification capacity will increase.

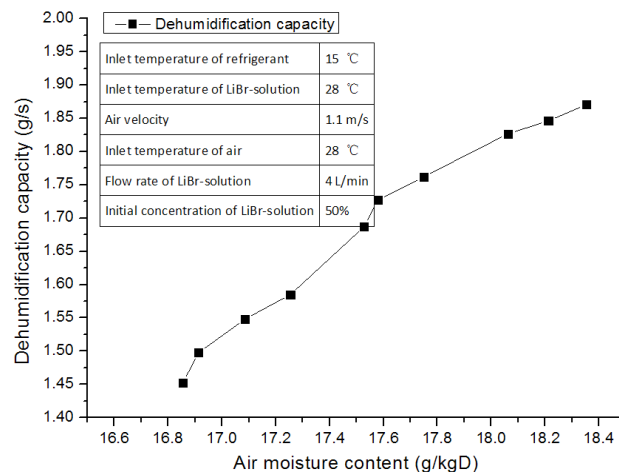


Fig. 6. Dehumidification capacity along with air moisture content.

### 3.2. Desorption performance in condensing regenerator

#### 1) Influence of air velocity

Fig. 7 shows the regeneration capacity in the condensing regenerator along with the air velocity, the other parameters in the condensing regenerator keep constant which also shown in Fig. 7. The regeneration air comes from the outdoor, its temperature is around 32 °C. When the air velocity increase, the heat and mass transfer will enhance, and the water vapor partial pressure difference between the regeneration air and the LiBr-solution will increase, then, the regeneration capacity will increase.

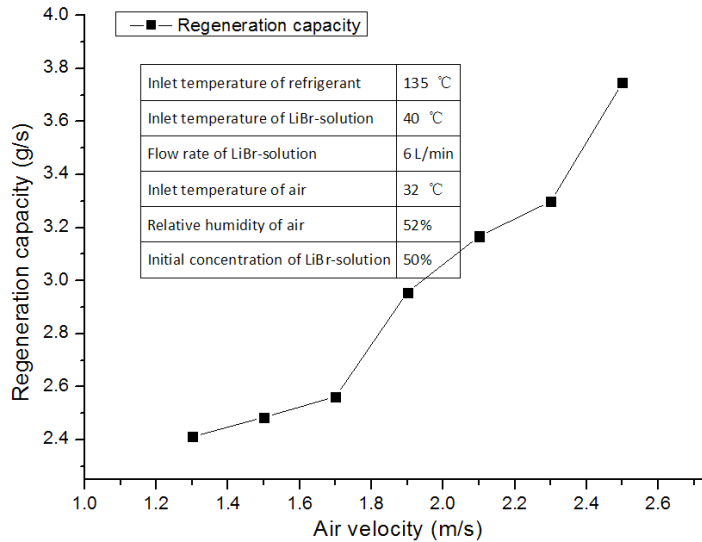


Fig. 7. Regeneration capacity along with air velocity.

## 2) Influence of LiBr-solution flow rate

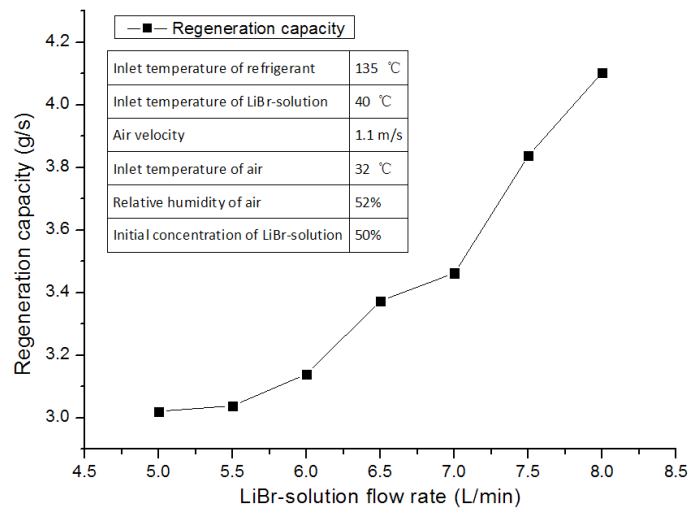


Fig. 8. Regeneration capacity along with LiBr-solution flow rate.

Fig. 8 shows the regeneration capacity in the evaporative dehumidifier along with the LiBr-solution flow rate, the other parameters in the condensing regenerator keep constant which also shown in Fig. 8. As mentioned above, the condensing regenerator is made up of 6 finned tube heat exchanger, therefore, when the LiBr-solution flow rate increase from 5.0 L/min to 8.0 L/min, the film is fully invaded in the finned surface, the heat and mass transfer enhance, and then the water vapor partial pressure between the solution the moist air will increase, as a result, the regeneration capacity will increase.

#### 4. Conclusions

In this study, heat pump is applied in a LiBr liquid desiccant system as the cooling and heating energy which named as evaporative dehumidifier and condensing regenerator respectively. A series of experiments along with inlet parameters are done to test the performance of absorption and desorption process. According to the experiments results, low temperature, appropriate solution flow rate and high air velocity is benefit to absorption process in evaporative dehumidifier; while high air velocity and high solution flow rate is benefit to the desorption process in the condensing regenerator.

#### Acknowledgements

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#### References

- [1] J. Wurm, D. Kosar, T. Clemens, Solid desiccant technology review, *Bull. Int. I. Refrig.* 82 (2002) 2-31.
- [2] E.E. Anyanwu EE, Review of solid adsorption solar refrigeration II: An overview of the principles and theory, *Energy Convers Manage.* 45 (2004) 1279-95.
- [3] D.C. Wang, Y.H. Li, D. Li, Y.Z. Xia, J.P. Zhang, A review on adsorption refrigeration technology and adsorption deterioration in physical adsorption systems, *Renew. Sust. Energ. Rev.* 14 (2010) 344-53.
- [4] B.R. Hughes, H.N. Chaudhry, S.A. Ghani, A review of sustainable cooling technologies in buildings, *Sust. Energ. Rev.* 15 (2011) 3112-3120.
- [5] A.A. Kinsara, M.M. Elsayed, O.M. Al-Rabghi, Proposed energy-efficient air-conditioning system using liquid desiccant, *Appl. Therm. Eng.* 16 (1996) 791-806.
- [6] C.K. Ahmed, P. Gandhidasan, A. Al-Farayedhi, Simulation of a hybrid liquid desiccant based air-conditioning system. *Appl. Therm. Eng.* 17 (1997) 125-134.
- [7] A.C. Oliveira, C.F. Afonso, S.B. Riffat, Thermal performance of a novel air conditioning system using a liquid desiccant, *Appl. Therm. Eng.* 20 (2000) 1213-1223.